

The small cells which develop in great quantity appear at first to be bi-nucleate (Text-fig. 29, A). These small cells function directly as asci. They enlarge and the number of nuclei increases (Text-fig. 29, B). A maximum of 8 very densely staining small bodies which are interpreted as nuclei have been seen in these cells (Text-fig. 29, C).

The appearance of the developing asci just prior to spore formation suggests that at least four, and possibly eight, spores start to form, but almost at once all but two cease further development and are crushed against the ascus wall (Text-fig. 29, D, E). The earliest sign interpreted as the beginning of ascospore formation is the appearance of non-staining circular areas associated with densely staining small granules, probably nuclei (Text-fig. 29, D). The spores elongate, becoming fusiform (Text-fig. 29, G) with thick refractive walls at maturity.

By the time all spores are mature, the ascocarp wall has become very thin and fragile and appears to disintegrate without any special line of dehiscence, leaving the mass of spores free (Pl. xv, fig. 2). In media rich in carbohydrates, ascocarps are large and produce numerous spores. Smaller ascocarps, containing only a few spores, are produced under starvation conditions.

#### Relationships.

The very reduced and simplified nature of the reproductive system makes purely speculative any interpretation of the structure and any suggestion of possible relationships. The terminal cell of the ascocarp initial may be regarded as a vestigial trichogyne. The central cell clearly functions as an ascogonium, and the subsidiary cells cut off from it and the subsequently developed mass of cells which function as asci may be regarded as components of ascogenous hyphae which, instead of remaining attached, separate from each other as soon as they are formed. Direct functioning of cells of the ascogenous hyphae as asci has been described by Emmons (1935) in a number of species of *Penicillium*. In these, chains of 5-6 asci develop directly from cells of the ascogenous hyphae.

A more precise picture of nuclear behaviour in the developing ascogonium and asci is required to throw further light on the relationships of this fungus.

#### Acknowledgements.

The fungus was obtained in culture by Mr. W. J. Scott, and to him I wish to express my grateful thanks for permitting this study to be made.

The development of the aleuriospores was first observed by Mr. P. R. Maguire, technologist of the C.S.I.R.O. Food Preservation Laboratory, in the course of studies on the growth of the fungus at different relative humidities. I wish to express my grateful thanks to him for drawing them to my attention and for providing a number of photographs illustrating their development. I also wish to thank Miss E. M. Wakefield for her advice and suggestions.

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#### XEROMYCES BISPORUS, gen. et sp. nov.

Mycelium in culture white, radiate; hyphae 4-10 $\mu$  wide, average 5-6 $\mu$ , septate, multinucleate; nuclei minute. Aleuriospores terminal on lateral branches 20-40 $\mu$  long, occasionally longer; usually 1-celled, but occasionally 2-3 celled; unicellular spores globose to pyriform, smooth with moderately thick wall, 15-18  $\times$  11-14 $\mu$ . Multicellular spores 17-35  $\times$  11-15 $\mu$ .

Ascocarps pale yellow, 55–150 $\mu$  (average 110 $\mu$ ) in diameter, the wall fragile at maturity, disintegrating without definite line of dehiscence. Asci 8–12 $\mu$  in diameter at maturity, spherical. Ascospores 2 per ascus, fusiform, 9–11  $\times$  4  $\times$  5 $\mu$  (average 10  $\times$  4  $\times$  5 $\mu$ ), smooth with moderately thick walls (average 1.5 $\mu$ ), pale yellow in mass. Ascocarp arising as a short lateral branch of 3 cells, a cap cell, a central cell and a stalk cell. The stalk cell producing 4 branches which enfold and form a wall around the central cell. Asci produced by division of the central cell, few to many per ascocarp. Antheridium absent.

Mycelium in cultura album, radiatum; hyphae 4–10 $\mu$ , latae, septatae, multinucleatae; nuclei minute. Aleuriosporae in ramis lateralibus terminales, 20–40 $\mu$  longa, plerumque unicellulares sed aliquando 2–3-cellulares; sporae unicellulares globulares vel pyriformes, 15–18  $\times$  11–14 $\mu$ , laeves parietibus crassiusculis, sporae multicellulares 17–35  $\times$  11–15 $\mu$ .

Ascomata pallido-flava, 55–150 $\mu$  diametro, parietibus in maturitate fragilibus, sine linea distincta dehiscendiae disrumpentia; asci in maturitate 8–12 $\mu$  diametro, globosi; ascosporae in quoque asco duae, fusiformes, 10  $\times$  4  $\times$  5 $\mu$ , in cumulo pallido-flavae, laeves, parietibus crassiusculis.

Ascoma ut ramus brevis lateralis natum, cellarum trium compositum nempe pilei-cellulae, cellulae mediae et pediculi-cellulae; cellula basalis ramos quattuor ferens, cellulam mediam amplectentes et circa eadem parietem formantes; asci divisione cellulae mediae producti, in quoque ascomati pauci vel multi; antheridium nullum.

#### EXPLANATION OF PLATE XV.

Fig. 1.—Mycelium and aleuriospores.  $\times$  200.

Fig. 2.—Mature ascocarps in process of disintegration and liberation of spores.  $\times$  400.

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ABNORMALITIES IN *LINUM USITATISSIMUM* L.

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(Plates xvi-xvii; twenty-two Text-figures.)

[Read 25th November, 1953.]

*Synopsis.*

Abnormalities noted in *Linum usitatissimum* during genetical investigations of rust resistance at Sydney University are briefly described and illustrated with text figures and photographs. These include polyembryos, leaf and cotyledon abnormalities, abnormalities of the stem and chlorophyll deficiencies, etc.

All but the leaf abnormalities appear to be more common in hybrids than varieties. It is suggested that this reflects genetic imbalance in the hybrids.

*Introduction.*

Abnormalities were noted during genetical investigations at Sydney University of rust resistance in *Linum usitatissimum* L. Busse and Burnham (1930), Shibuya (1939), and Millikan (1951) have reported stem abnormalities, and Crooks (1933) described compound leaves in this species.

Other abnormalities have been reported frequently in other species (White, 1945, the biology of fasciation, and Waterhouse, 1953, polyembryony in cereals).

The abnormalities observed in double cross,  $F_2$  and varietal material during 1952 are dealt with below.

## POLYEMBRYONY.

Twin embryo seeds were detected, soon after germination on blotting paper, by the emergence of two roots (Plate xvi, fig. 14.). The twins were always separate and gave identical rust reactions when tested with races to which the source material was segregating in ratios of 1:1 or 3:1 resistant:susceptible (Table 1). One was sometimes sturdier than the other, and neither was as sturdy as normal seedlings for the first few weeks.

They may be due to single fertilization followed by splitting of the young zygote, or result from double fertilization of two female by two male gametes. The identical rust reactions indicate genetic identity of the female gametes if more than one is involved, but gives no indication of single or double fertilization, since the pollen parent of the double cross seed was non-segregating F257. But single fertilization followed by twinning is the more probable process in *Linum* (Eames, personal communication). The one occurrence in  $F_2$  material which could have refuted this process, rather confirmed it. Waterhouse (1953) has attributed polyembryos in the cereals to the same process.

## COTYLEDON ABNORMALITIES.

There were two types of abnormalities: (1) Those with three (Plate xvii, figs. 15*a*, 15*b*, 16*a*) and (2) those with four cotyledons (Plate xvii, figs. 3, 4; Text-figs. 11-14) completely separated from each other or fused together in pairs for varying lengths from the base (Plate xvii, 16*a*).

Each cotyledon had its own vascular system and an axillary bud. One type 2 seedling with two pairs of cotyledons united at the base had an interesting arrangement of two pairs of axillary buds (Text-fig. 14) vertically opposed to each other in the two axils.

*Effect of Cotyledon Complex on Phyllotaxy.*

This effect, as distinct from the usual environmentally induced deviations from the norm, could be assessed in those sowings in which all seedlings with normal cotyledons had a normal decussate arrangement at the lower nodes. There was no significant

deviation from the norm in seedlings with fused cotyledons (Plate xvii, fig. 16a; Text-fig. 1). In those with complete separation of the cotyledons the phyllotaxy varied from normal decussate (Plate xvii, fig. 15b) to whorls of three leaves (Plate xvii, fig. 15a), with intermediate types alternating single or whorls of three leaves with the usual opposite pairs (Text-figs. 2 to 10). In others the arrangement was spiral, and sometimes quite irregular.

#### *Formation of Cotyledon Abnormalities.*

Type 1 abnormal seedlings with three equal sized cotyledons evenly disposed about the stem, and successive whorls of three leaves, probably commenced as tripartite embryos. The others must have commenced as bipartite embryos, laying down two primary cotyledon primordia and establishing the tendency to a decussate phyllotaxy. One cotyledon primordium has then over-differentiated. The complex has usually separated along the mid-line giving rise to two cotyledons of equal size, often closely appressed to each other. Lateral separation has occurred at least once, and possibly accounts for the small cotyledons sometimes observed (Plate xvii, fig. 18).

In a Walsh hybrid seedling one of the three cotyledons was separated from the other two by a distinct internode (Plate xvii, fig. 7). Since it lay in the same radius as one above it, it could scarcely have derived from the bifurcation of one of two original primordia, but must rather have been a premature and unrelated primordium.

TABLE 1.  
*Details of Polyembryos.*

Pedigree of Polyembryos.	Race of Rust.	Reaction of Seedlings.	Expected Ratio of Resistant to Susceptible Plants.
(Ottawa 770B × Bison) × F257 <sup>1</sup> .. ..	2	Both immune.	1 : 1
(Bison × Ottawa 770B) × F257 .. ..	2	Both immune.	1 : 1
(Bison × Ottawa 770B) × F257 .. ..	Not tested.		Two sets of twins.
(Argentine F11 × Bison) × F257 .. ..	2	Both immune.	3 : 1
(Italia Roma × JWS) × F257 .. ..	6	Both susceptible.	1 : 1
(Bolley Golden × Bison) × F257 .. ..	6	Both immune.	1 : 1
(Argentine F11 × Ottawa 770B) × F257 .. ..	Not tested.		
(Argentine F11 × Newland) × F257 .. ..	Not tested.		
Punjab × Concurrent .. ..	6	Both susceptible.	3 : 1
Ottawa 770B .. ..	Not tested.		
F257 .. ..	Not tested.		

<sup>1</sup> F257 susceptible to all Australian races of rust.

#### *Pedigree of affected seedlings.*

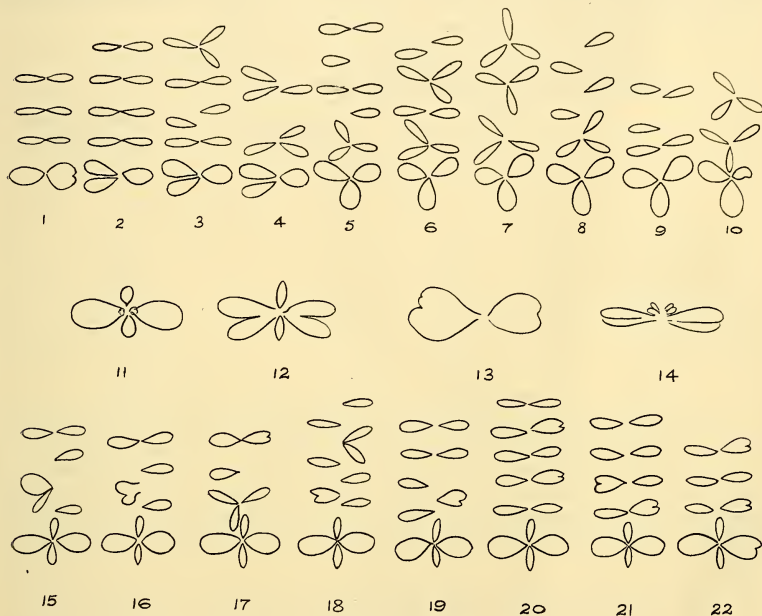
Type 1.—(Koto × Punjab) × F257, (Argentine F11 × F257) × F257, (Morye × Abyssinian) × F257, (Bolley Golden × Koto) × F257, 2 (Italia Roma × Bison) × F257, (Abyssinian × Tammes' Pale Blue) × F257, (Ottawa 770B × Argentine F11) × F257, (F257 × Ottawa 770B) × F257, (J. W. S. × Newland) × F257, (Argentine F11 × Bison) × F257, Williston Golden × Bison, Very Pale Blue Crimped × Koto, Very Pale Blue Crimped × Bison, F257 × Williston Golden, Very Pale Blue Crimped × F257, Punjab × Very Pale Blue Crimped, Walsh × F257, Leona × F257, Morye × F257.

Type 2.—(Argentine F11 × Concurrent) × F257, (Morye × Abyssinian) × F257, Ottawa 770B × Morye.

#### LEAF ABNORMALITIES.

Three types of leaf abnormalities were noted: Compound leaves, Whorls of three or more leaves, Cone- and fan-shaped abnormalities. The first two have received a brief mention (Crook, 1933); reference to the last group is made by Forsyth and Schuster (1943).

Compound leaves showed varying degrees of differentiation into component subleaves, from slight terminal indentation (Plate xvi, fig. 10) to almost complete separation to the base (Plate xvi, fig. 12). Each subleaf had its own vascular system. There were usually two or three subleaves and rarely more than four. Compound leaves were often associated with another compound leaf or one or two normal leaves at the same node. But the number of subleaves and leaves together rarely exceeded four and never exceeded six.



Text-figures 1-22.

1 to 10. Varying effects of cotyledon complex on phyllotaxy.

1 and 2, Normal decussate; 3, Irregular; 4, Three-leaf whorls with leaves slightly displaced along the vertical axis; 5, Alternation of 3-leaf whorls, single leaves and opposite pairs; 6, Alternating 3-leaf whorls and opposite pairs (up to the thirteenth node); 7, Even 3-leaf whorls; 8, Basal 3-leaf whorl, spiral above; 9, Irregular; 10, Whorl of three cotyledons, one very small. Even 3-leaf whorls above.

11. Whorl of four cotyledons, two large and two small, and two growing points.

12. Two pairs of partially united cotyledons with two basal leaves.

13. Two pairs of almost completely united cotyledons, showing lateral separation of one pair.

14. Two pairs of partially united cotyledons and two pairs of vertically opposed axillary buds.

15-19. Skewed phyllotaxy resulting from apparent fusion or incomplete separation of contiguous leaf primordia.

20, 21. Apparent bifurcation of a single leaf primordium with no appreciable effect on phyllotaxy.

22. Walsh seedling showing terminal bifurcation of one cotyledon and the two leaves immediately above in the same radius.

Text-figures 11-14,  $\times 1$ ; others  $\times 0.8$  approx.

Whorls of three or four leaves and rarely five, were often associated with bifurcated and fasciated stems, but were common on normal seedlings.

Cones consisted of a complete whorl of four undeveloped leaves (Plate xvi, figs. 6a, 6b) with only the slightest terminal separation. The tissue sometimes seemed to have

been under strain, resulting in rupture from the base to varying degrees (Plate xvi, fig. 5), culminating in an everted cone (Plate xvi, fig. 11). The shoot continued to grow up through the cone without any marked distortion (Plate xvi, fig. 1).

Cone and fan abnormalities were noted by Forsyth and Schuster (1943) among seedlings seed-treated with spergon at a frequency regulated by the dose of the fungicide. The seedlings dealt with in the present paper were not treated with spergon, and the abnormalities could not be attributed to the action of any chemical.

Seedlings with abnormalities at two nodes (Plate xvi, fig. 10) were not uncommon. Those with three were rare. One plant had six affected nodes.

TABLE 2.  
*Internode Length of Normal and Abnormal Seedlings in  $\frac{1}{8}$ "*, Noted 10.8.51. F257.

	Normal Seedlings.		Seedlings with Fan Type Abnormalities Above First Internode.		Seedlings with Cone Abnormalities Above First Internode.	
	First.	Second.	First.	Second.	First.	Second.
Average internode length ..	1.4	15.1	4.0	14.7	4.5	20.3
Number of seedlings.. ..	18		10		6	
Range of length .. ..	1-3	8-22	2-6	9-23	3-6	15-25

#### *Localization of Leaf Abnormalities.*

Whorls of leaves and compound leaves occasionally occurred on secondary, particularly fasciated, side shoots. Cones were always restricted to the primary shoot.

The three groups were mostly confined to the first five nodes and seldom found above the seventh (Table 5), but compound leaves with slight terminal indentations have been found at higher levels, e.g., single plants in hybrid lines of Very Pale Blue Crimped  $\times$  Punjab and Morve  $\times$  Newland; at node 9 in the former and 8" up the stem in the latter.

TABLE 3.  
*Length of Internodes in Centimetres of Eleven Normal and Six Abnormal Seedlings<sup>1</sup> of an F6 Line of Walsh Parentage, Sown 22.7.52.*

	Second Internode.	Third Internode.	Fourth Internode.
Average and range of length of internodes contiguous with abnormality.	2.8 2.8	2.11 1.9 to 2.5	1.9 1.7 to 2.4
Average and range of length of internodes non-contiguous with abnormality.	2.17 1.6 to 2.8	1.65 1.4 to 2.1	1.39 1.2 to 1.8

<sup>1</sup> Several with abnormalities at more than one node.

#### *Associated Features.*

Internodes contiguous with cone and fan type abnormalities were generally longer than usual (Plate xvi, figs. 7, 8). The internode between the cotyledons and first leaf pair in F257 was usually hardly visible. But all F257 seedlings with cone- and fan-shaped abnormalities at the first node in 1951 had a distinct internode (Plate xvi, fig. 2) below, and a markedly longer than normal internode above the affected nodes with cones (Plate xvi, fig. 4a, c; Table 2).

The internodes contiguous to cone and fan abnormalities in an F6 line of Walsh parentage were again longer than normal (Table 3).